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The effect of preservatives on the inflammability of wood

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THE EFFECT OF PRESERVATIVES ON THE INFLAMMABILITY OF WOOD

by

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THESIS

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FOREWORD

In preparing the descriptive matter in this thesis free use has been made of Bulletins published by the American Wood Preservers A'ssn. and the U.S. Dep't. of Agriculture, Forest Products Laboratory.

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Preservative treatment of timber has been practiced in this and foriegn countries for nearly a century and many effective materials and methods have been developed. The engineer may choose any one of these and be sure of getting greater life from his timbers at a saving in cost. In considering the use of treated timber the question of economy is naturally of first importance. There may, of course, be other advantages in using treated timber, such as conservation of the supply of timber within reasonable distance from the mine, the ability to use species of the lowest durability, and the greater freedom from mining interruptions caused by frequent timber renewals. The matter of greatest importance, however, is; will the use of treated timber effect a financial saving? The answer to this question will depend mainly upon the relative first cost, and the relative life of the treated and untreated timber respectively and the cost of timber renewals in each case.

The various preservatives developed for the treatment of timbers protect the timber from decay and certain kinds of insects. Whether some of the preservatives now in use act as fire-retardants and

and reduce the inflammability of the timber is a question that should stand considerable investigation.

Considered as to fire resistance the important properties of wood, and for that matter other structural materials, are (1) the extent to which it resists combustion, (2) its capacity to retain strength properties under fire conditions, and (3) its resistance to the passage of heat through it. The relative importance of these properties varies for the different uses. The first property is of primary importance from the standpoint of the reduction of damage due to fire; the second is significant in timbers for structural purposes; and the third is of importance for bulkheads, fire, and ventilation doors.

Obviously, small scale laboratory tests on samples of treated wood are not a sufficient measure of the fire resistance of the completed structure. Performance ratings on such assemblies must be arrived at by the full scale tests under the customary methods in use for such purpose.

OBJECT OF THESIS

It is the purpose of this thesis to present some data on the fire-resistance and inflammability of wood, treated with preservatives commonly used for mine timber.

WOOD PRESERVATIVES (1)[1], (2), (3), (4)

Many materials extend the life of wood by reducing the deterioration by decay and animal life. Some are more effective than others and all possess certain disadvantages that limit their use, as well as advantages that make them especially suitable for specific purposes. These preservatives fall into three general classes: those of an oily nature, like creosote, which are relatively insoluble in water; the salts that are injected into wood in the form of water solutions; and those in which the toxic constituent is carried in some volatile solvent other than water.

COAL-TAR CREOSOTE

Coal-tar creosote is the most important and most generally useful preservative. Its advantages are (1) its high toxicity, which makes it extremely poisonous to wood destroying fungi and insects, (2) its relative insolubility in water and its low volatility which imparts to it a degree of perm-

1 Numbers in parentheses refer to bibliography.

anance under the most varied conditions; (3) its ease of application; (4) the ease with which its depth of penetration can be determined; and (5) its general availability and relatively low cost.

Although for general outdoor service in structural timbers there is, as yet, no better preservative than coal-tar creosote for some special purposes it has certain properties that are a disadvantage. Without question, freshly creosoted timber can be ignited easily and will burn readily, producing a dense smoke. The extent to which creosoted wood should be regarded as a fire hazard has never been satisfactorily determined.

The odor of creosoted wood is unpleasant and may be found objectionable in poorly ventilated underground openings. Workmen sometimes object to the use of creosoted wood because it soils their clothes and because it sometimes burns the skin of the face and hands, causing an injury similar to sunburn. However, creosoted timber has no other serious effect on the health of workmen handling or working with it.

The color of creosote and the fact that it usually cannot be painted over satisfactorily

makes it unsuitable for certain types of structural use where appearance and paint receptivity are of major importance.

WATER-GAS-TAR CREOSOTE

Water-gas-tar creosote is made from water-gas-tar in much the same manner that coal-tar creosote is made from coal-tar. Although water-gas-tar creosote is not considered so toxic or so generally effective as coal-tar creosote, it is known to be a good preservative; wood that has been deeply penetrated with it will have satisfactory resistance to decay. Aside from a toxicity, the advantages and disadvantages of water-gas-tar creosote are generally similar to those of the coal-tar product.

TAR

Tars are seldom used by themselves for preserving wood, because obtaining good penetration with them is usually difficult and because they are less poisonous to wood destroying fungi than creosotes. Service tests have demonstrated that surface coatings are of little value.

PETROLEUM

Crude petroleum, topped petroleum, fuel oil, and waste crank-case oil are frequently suggested as possible wood preservatives and many experiments

have been made with these. Experience has shown, however, that petroleum oils used alone are not satisfactory.

ZINC CHLORIDE

Zinc chloride is the water-soluble preservative most extensively used in the United States. The principal advantages of the salt are relative cheapness, general availability, uniformity of product, cleanliness, lack of odor , ease of shipment, and lack of fire hazard. Its chief disadvantage is its solubility in water, which permits it in time to be leached out of the wood under moist conditions. The water that is injected with it temporarily adds considerably to the weight of the wood and because of this the treated timber should be dried before using.

Zinc chloride is shipped either in solid(fused) form or in concentrated solutions. When freight haul is not too great, the concentrated solution, usually 50% strength, is shipped in drums or tank cars. For long freight hauls the salt is shipped in solid form in air-tight drums. For use in treating wood, water solutions of 3 to 5% are prepared from the concentrated material.

SODIUM FLUORIDE

Sodium fluoride, in mixture with other materials, has been used to a considerable extent in Europe for preserving wood, especially mine timbers. In United States it has been used alone experimentally in railway ties and in mine ties and timbers since 1914. It is not so soluble as zinc chloride, since the maximum strength of the solution is about 4%. For the most part its advantages and disadvantages are similar to those of zinc chloride. The chief disadvantage is its relatively high price, which in recent years has been roughly one and one-half times that of zinc chloride. Sodium fluoride is a valuable ingredient in several proprietary or patented preservatives.

ARSENIC

Arsenic in various forms, either alone or mixed with other substances, has been used as a wood preservative for a number of years, and a considerable quantity of poles, ties and other material treated with it is now in service.

COPPER SULPHATE

Copper sulphate which has been used in Europe as a wood preservative for many years, is

known to be effective in retarding decay. It is no more effective than zinc chloride or sodium fluoride, however and has no special advantages over them. The disadvantage of this preservative is the fact that it attacks iron and steel and therefore cannot be used in ordinary treating equipment.

MERCURIC CHLORIDE

Mercuric chloride was first used for the preserving of wood in 1705, and its use was again reported in 1767.The first commercial treating plant in the United States, built in 1848, used this preservative and is still doing so. The use of mercuric chloride in the United States, however, has not greatly increased in all this time. Undoubtedly it is effective in prolonging the life of wood but its relatively high price, its extremely poisonous character, and its corrosiveness to metal have militated against it.

Many preservatives are sold under trade names of various kinds. Some of them are ordinary coal-tar creosote, or coal-tar creosote that has been modified slightly by taking out some of the solid ingredients. Others have had lighter fractions removed, making them higher boiling than the ordinary

run of creosote. In the main, preservatives derived from coal-tar creosote are good preservatives and may be used with assurance.

In a second group are preservatives injected in water solutions, whether or not these are good depends upon the materials of which they are composed. A few, containing arsenic or sodium fluoride, give what appear to be promising results. Included in this group are Ac-Zol and Wolman salts.

AC-ZOL

Ac-Zol is a proprietary preservative which originated in Belgium about 1911. It is the result of the action of phenol on copper and zinc oxides. These phenolates are kept in solution by ammonia, which evaporates and leaves the salts in the wood. Ac-Zol is shipped in concentrated solution, which is diluted with 94 parts of water, for use in treating timber.

WOLMAN SALTS

Wolman salts is a preservative originating in Germany. Three salts are now available in United States. (1) Triolith is composed chiefly of sodium fluoride to which certain bi-chromates and nitrated phenols have been added. This salt is recommended for ties, mine timbers and general purposes. (2) Minolith is triolith to which chemicals such as

borax or rock salt have been added to make the timber more fire resistant. (3) Tanolith is triolith to which an arsenate salt has been added to make the timber more resistant to the attacks of insects.

Wolman salts being water soluble some question might arise as to the possibility of the salt leaching out under moist conditions. The following statements are taken from the manufacturers bulletins.

"Unlike other salt preservatives which will totally liquefy within twenty-four hours from moisture drawn from the surrounding air Wolman salt that has been exposed since 1918 has never taken on enough moisture to even cake or harden."

"Di-nitrophenol is classed as a dye product with a well recognized effect of fixation on wood fibre. The chromates added as neutralizing and mordant ingredients of Wolman salt are the most common form of mordant used in the dye industry, and unquestionably contribute to a noticeable degree in the diffusion and penetration of the salts, particularly of the di-nitrophenol. This is very evident when phenol-fluoride mixtures are used without the chromates, the di-nitrophenol then markedly filtering out in

a thin layer at the surface."

"In discussing the subject of elimination or leaching of water soluble preservatives, it is important to have in mind just how such elimination can take place, in order to form correct conclusions as to the length of time during which an effective amount of preservative will remain in the timber. Since vapor cannot transport salt, as is evidenced in every laboratory where determination of salt content of a solution is arrived by evaporating of the water and weighing the remaining salt, the removal of water soluble preservative can only occur in one of three ways:

1. Water finding its way into the interior, dissolving the salt, and running out again as water in liquid form. This can only occur under very unusual circumstances, the resistance of wood to the movement of water through its structure being very great.

2. Movement of salt, under attraction of external moisture, toward the surface of the timber whence it might be washed away by water or blown away by drying air currents. This will take place in the case of a hygroscopic salt, but the inertness of the Wolman salt ingredients assures against this form of

removal. There cannot be any movement of the Wolman salt due to the powerful fixation of the dye like character of the ingredients that make up the preservative. It is actually dyed into the wood, much in the same manner as fast dye is put into fabric.

3. Diffusion will take place whenever a strong solution of salt is in contact with another body of water, unless there has been a powerful fixation of the salts within the wood fibres. The degree to which this osmosis occurs depends upon completeness of solution of the salts in the interior and the intimacy of contact of such interior solution with standing water outside. Under all practical conditions it is likely to be very slow as the penetration of water into the interior of timber to such an extent as to provide actual liquid contact necessary for such diffusion requires many days immersion and in service conditions such long continued immersion does not normally occur except in piling."

"The practical experience with timbers under very extreme condition of moisture such as in some of the deep, wet and very warm Silesian mines, where long stretches of Wolmanized framing erected in 1911 are still in good condition with their bases

in running water, gives effective practical support to the above considerations."

METHODS OF APPLYING WOOD PRESERVATIVES(2),(5),(6),(7)

The amount of protection given by a good preservative depends upon the absorption and penetration obtained. Some preservative processes are simple and inexpensive, while others are complicated, requiring expensive equipment. The protection obtained from the simplest and cheapest processes, although it will generally more than pay for the work, will not be so great as that obtained with the more thorough but also the more expensive methods.

For satisfactory results with any treating process the timber should be sound, and in proper condition for treatment. It should be peeled, free from decay and for best results, seasoned. Preservatives will not make weak timber strong nor restore the strength of timber that has been partially destroyed by decay. Further, except in material of small dimensions, the preservative and the heat of the process can not be expected always to kill all fungus growth in an infected or partially decayed stick.

Peeling round or slabbed timber is

necessary to enable it to season quickly, to avoid decay, and insect damage and also, because preservatives will not penetrate bark satisfactorily.

Strips of even thin inner bark may prevent penetration.

Patches of bark left on during treatment usually fall off in time and expose untreated wood, thus permitting decay to reach the interior of the stick.

Applying surface treatment to green or wet wood is practically useless, because preservative cannot penetrate wood that is already full of water. Either kiln or air seasoning is satisfactory but air seasoning is the most widely used and is the cheapest and most effective.

Wood that is resistant to penetration by preservatives is sometimes incised before treatment to permit deeper and more uniform penetration. To accomplish this, the timber passes through a machine having horizontal and vertical rollers equipped with teeth that sink into the wood to a pre-determined depth, usually one-half to three-quarters of an inch. The teeth are spaced so as to give the desired distribution with the minimum number of incisions.

Preservatives will penetrate into wood much further in a longitudinal direction than in a direction perpendicular to the grain of the stick. The incisions expose end grain surfaces and permit longitudinal penetration.

The incising of timber has proved very effective.

PAINTING OR SPRAYING

Painting or spraying timber with a preservative is a cheap and rapid method of treatment. The penetration is so slight, however that rough handling or checking will later expose the timber to attack by fungi.

DIPPING

The dipping process, used with creosote and similar preservatives, is simply the submerging of the timber in hot preservative for a short time, usually 5 to 15 minutes. The penetration obtained, in exceptional cases, may be one-fourth of an inch but usually it will be one-sixteenth of an inch or less. The dipping process gives greater assurance than the painting or spraying that the timber will be thoroughly covered with the preservative and should result in a longer life.

HOT AND COLD BATH

The hot and cold bath treatment is the most effective of the non-pressure methods. The treatment consists in heating the wood in preservative in an open tank for several hours, and then quickly submerging it in cold preservative for several hours. The principle involved is that on heating the air and moisture in the wood expands. When cooling takes place, whether fast or slow, the air contracts and the the moisture condenses, creating a partial vacuum and the preservative is drawn into the wood. The preservative commonly used is coal-tar creosote but water soluble preservatives, such as zinc chloride, may be used.

PRESSURE METHODS

The most effective method of applying wood preservatives employs pressure. Pressure processes differ from one another in a few details but the principle is the same in all. The wood, placed on steel trucks, is run into a long steel cylinder, which is then closed and filled with preservative. Pressure then forces the preservative into the wood until it has absorbed the required amount. This amount is considerable, and a deep penetration is obtained. Two principal types of pressure treatment, the full-

cell and the empty-cell, are in common use.

FULL-CELL PROCESS

The full-cell creosoting process is widely used when the retention of a maximum quantity of preservative is desired. The steps in this process are as follows: (1) After the charge of timber has been placed in the treating cylinder a preliminary vacuum is applied for one-half hour or more to remove the air from the cylinder and as much as possible from the wood. (2) The preservative, previously heated to the desired treating temperature, is admitted to the cylinder without the admission of air. (3) After the cylinder has been filled, pressure is applied until the required absorption of preservative is obtained. (4) When the pressure period has been completed the preservative is withdrawn from the cylinder. (5) A short final vacuum is usually applied to reduce dripping.

EMPTY-CELL PROCESS

The object of empty-cell treatment is to obtain deep penetration with low net retention of preservative. Two empty-cell treatments are commonly used.

The Rueping empty-cell process has been

widely used, both in Europe and in the United States. The general procedure is as follows: (1) Air under pressure is forced into the treating cylinder, which contains the charge of timber. The air penetrates some species easily, requiring but a few minutes application of pressure. In treating the more resistant species air pressure is maintained for one-half to one hour before admitting the preservative. Air pressures of 25 to 100 pounds per square inch, depending on retention of preservative desired are used. (2) Following the application of preliminary air pressure the preservative is admitted to the cylinder. During the filling period the pressure within the tank is constant. When the treating cylinder is filled with preservative the pressure is raised to a higher point and continued until the desired absorption is reached. (3) At the end of the pressure period the preservative is drained from the cylinder and a final vacuum removes the surplus preservative from the wood.

The second empty-cell process, the Lowry, differs from the Rueping in that it does not employ the initial air pressure. In the Lowry process the preservative is admitted to the cylinder without either an initial air pressure or a vacuum. The air

originally in the wood is imprisoned during the filling period. After the filling period pressure is applied and held until the desired absorption takes place.

DETERMINATION OF ABSORPTION

The following statement is quoted from the American Wood Preservers' Association's standard specification for zinc chloride. "Retention of Preservative: No charge shall contain less than 90% nor more than 110% of the quantity of preservative that may be specified; but the average retention of preservative by the material treated under any contract or order shall be at least 100% of the quantity specified. The amount of preservative retained shall be calculated on the basis of preservative at 100° F., from readings of working-tank gauges, or scales, or from weights before and after treatment of loaded trams on suitable track scales, checked as may be desired by the purchaser's representative."

Report of treatment with zinc chloride: Vacuum of 23 inches held for 1 hour. Charge treated to refusal. Maximum pressure, 175 lbs. Time, 2 hours and 10 minutes. Temperature 175 degrees F. high, 174 degrees F. low. Final vacuum 20 inches attained in

30 minutes, then broken and charge pulled. The lumber contained 200 cubic feet of material. The absorption by volume figured at 40% gives 80 cubic feet of 3 1/4% solution at 175 degrees, which figured at 62.6 lbs. per cubic foot, or a net absorption of 5,008 lbs., gives 162.76 lbs. of zinc chloride or 0.814 lb. per cubic foot.

Calculations for the absorption of other preservatives would be of a similar nature.

PROCEDURE FOR TESTS

All specimens treated were well seasoned Douglas Fir, 3/8 x 11/16 x 18 inches. Three preservatives were used for treating; creosote, 4% solution of zinc chloride and 10% solution of Wolman salts.

The present methods of treatment,with zinc chloride as the preservative, give satisfactory absorptions with 3 to 5% solutions.

The Wolman salt used for these tests was was a combination of the three Wolman salts, namely; triolith,minolith and tanolith. This combination of salt gives increased fire protection and termite protection.

The cycle of operations in treating a

specimen is as follows: (1) Placing timber in treating cylinder (Fig. 1). (2) Filling with preservative and raising to the proper temperature (150 to 170 degrees F.). (3) Applying pressure (52 to 55 lbs. per square inch.) (4) Draining preservative from cylinder. (5) Drying specimens.

This procedure was followed in treating all specimens with the different preservatives. In treating in this manner the assumption is made that different amounts of preservative will be absorbed by the wood because of the time element. In order to secure a comparison between freshly creosoted timber and creosoted timber that has had time for thorough drying some specimens were treated in September 1933 and others in February 1934.

INFLAMMABILITY TESTS (8), (9), (10)

Various attempts, resulting in many forms of tests, have been made to measure the inflammability or fire resistance of wood. In general these attempts may be classified under tests on samples of wood and tests on built-up assemblies under approximate fire conditions. Tests on built-up assemblies are expensive and are therefore limited in their application.

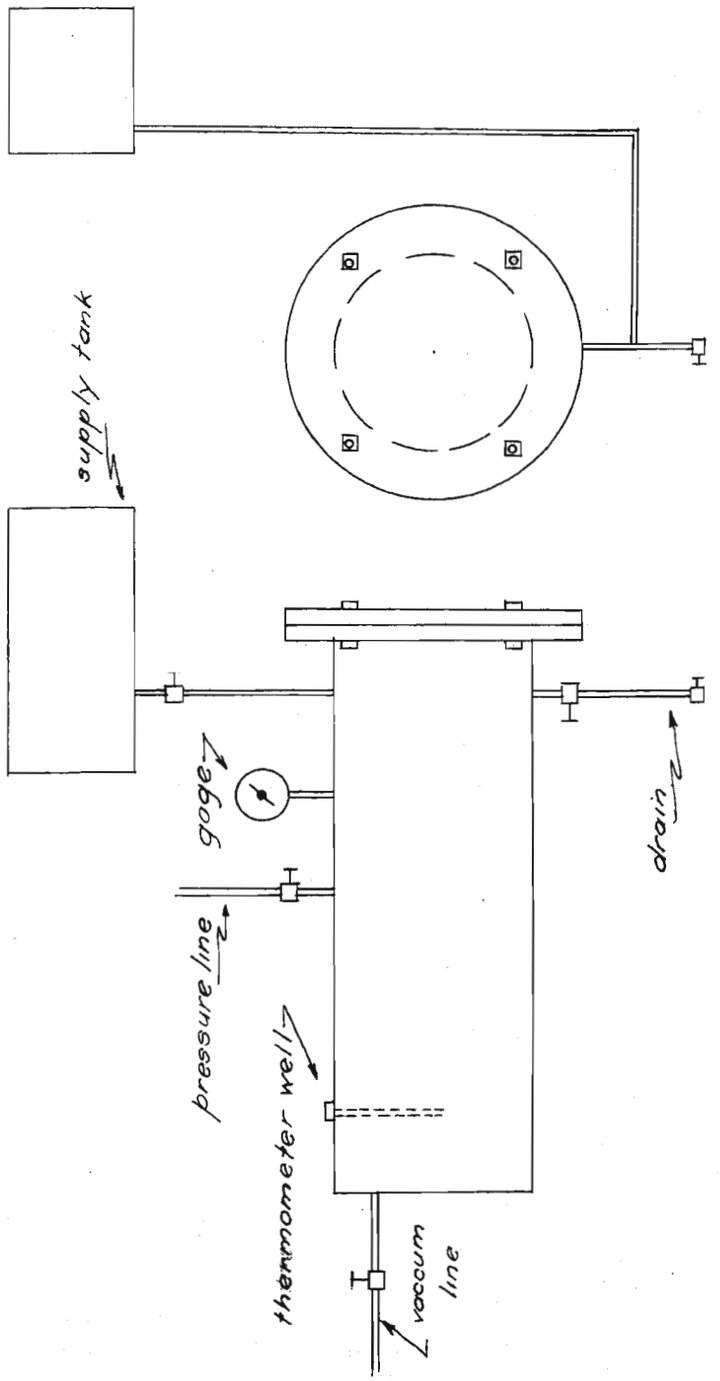

supply tank
gage
drain
pressure line
thermometer well
vacuum line

Fig. 1

The flame-penetration test by which a gas burner or blow-torch is applied to a piece of wood has been used by many as a measure of fire resistance. In some forms of this test, the time required for a flame to burn through a board or timber or for a loaded timber to fail when subjected to the flame is used as a measure of fire resistance. The depth of flame penetration in a board, the area of unburned wood in a timber, and the time required for a loaded timber in contact with the flame to fail are measures of the resistance of the wood to flame penetration.

A number of fire resistant tests are based on measuring the time of flaming and glowing of the wood which has been ignited and then removed from the source of ignition. Such tests as the "crib", "splinter", "shavings", "timber" and "muffle" are based on this principle. Most of these tests show differences in fire resistance between wood untreated and effectively treated with fire retardants, but the time required for ignition and of flaming and glowing after ignition depends upon so many conditions that such tests are of doubtful value as an accurate measure of fire resistance.

Closely related to the time required for ignition is the temperature of ignition. This test has been perfected until it is more precise and definite than the time of glowing and flaming but here again the ignition temperature may or may not measure the essential property of fire resistance. It is possible, for example, for a piece of wood that ignites at high temperature to continue to burn and give off more heat than a piece which ignites at a lower temperature.

In nearly all tests referred to comparatively small pieces of wood were used, and in most cases, the entire pieces were subjected in test to uniform temperatures. As a result, the entire specimen starts burning at the same time in most tests and affords no direct measure of the tendency of wood to spread flame.

To overcome the limitations of test methods used in the past, M.E.Dunlop of the Forest Products Laboratory, devised what is now commonly called the "fire-tube" shown in Fig. 2.

It is an apparatus which shows directly and progressively during the test the loss in weight and temperatures developed when a specimen of wood is

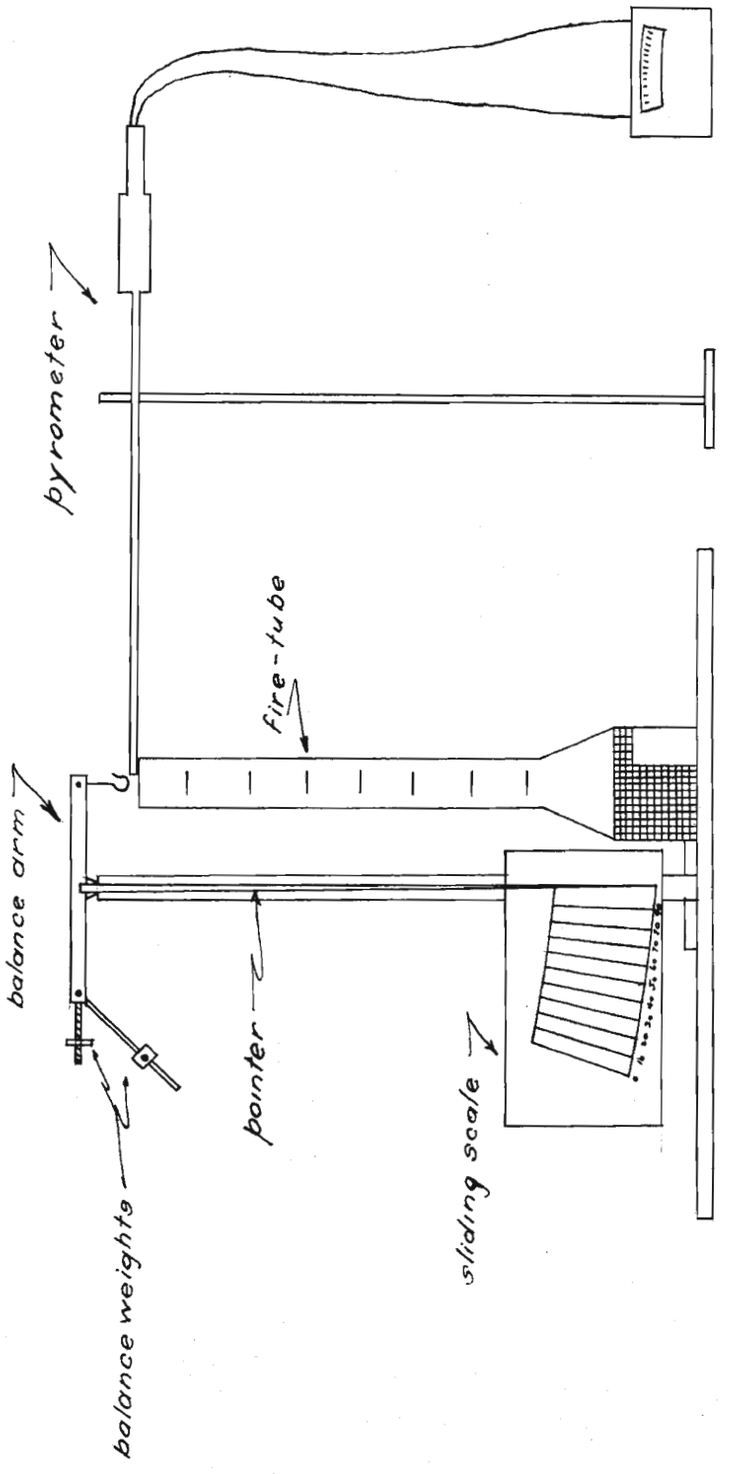

pyrometer
fire-tube
balance arm
pointer
sliding scale
balance weights

Fig 2

exposed to conditions approximating those existing in fires. The fire-tube test has a number of advantages over other forms of test that are commonly used. It is sensitive enough to show differences in the inflammability of different species of untreated wood or of the same species of wood at a different moisture content. It shows differences between effectiveness of different chemicals, and differences between various absorptions of the same chemical. Furthermore, the test results are expressed numerically and can be duplicated with a reasonable degree of accuracy.

The fire-tube used in these tests is similar, in construction, to the one developed at the Forest Products Laboratory. Due to the small size of the treating cylinder sticks 18 inches long were the maximum length treated. For burning in the fire-tube the sticks were cut to 12 inches.

The fire-tube is essentially an open, galvanized-iron tube in which the specimen is burned while suspended from a balance arm. A gas flame is applied to the lower portion of the specimen for one minute. To the balance arm is attached a pointer that indicates on a scale the percentage loss in weight

as the burning proceeds. The temperature at the top of the tube is measured by means of a pyrometer. As the wood is decomposed by the flame the coals that drop are caught in the bottom of the tube.

In testing any specimen the flame is placed under the specimen for one minute and then removed.

The temperatures built up at the top of the tube, after the removal of the initial flame, are due entirely to the combustion of the wood.

Temperature and percentage loss in weight readings are taken at one-half minute intervals. These readings are taken as long as the specimen continues to glow.

The results so far obtained, by the Forest Products Laboratory, with the fire-tube apparatus indicate that it is a reasonably accurate method of measuring the tendency of the wood to support combustion and that the test data can be expressed in definite numerical terms. The test apparently shows the tendency of wood to cause the spread of flame and the building up of temperature.

These characteristics are essentially important from the standpoint of fire hazard.

TABLES

Table No. 1

Average of four burning tests on untreated wood.

Time Minutes	Loss in weight Per cent	Temperature Degrees centigrade
1/2	5	103.7
1	15	170
1-1/2	26	208.7
2	38.5	243.7
2-1/2	52	272
3	63	295
3-1/2	72.7	301
4	78.2	291
4-1/2	79	265

Table No. 2

Average of three burning tests on creosoted wood. Treated for 30 minutes. September 1933.

Time Minutes	Loss in weight Per cent	Temperature Degrees centigrade
1/2	4.3	123.3
1	14	183.3
1-1/2	23.3	215
2	33.6	243.3
2-1/2	43	261.6
3	53.6	281.6
3-1/2	63	293
4	70.3	298
4-1/2	80.3	286.6

FIRE-TUBE TESTS ON UNTREATED WOOD

No. 1

Time min.	% loss in weight	Temp. degrees C.
1/2	5	95
1	13	160
1-1/2	25	200
2	38	240
2-1/2	50	270
3	62	300
3-1/2	73	305
4	78	290
4-1/2	78	265

No. 2

Time min.	%loss in weight	Temp. degrees C.
1/2	7	100
1	18	170
1-1/2	29	210
2	43	250
2-1/2	58	280
3	70	295
3-1/2	78	290
4	80	275
4-1/2	80	240

No.3

1/2	4	110
1	15	180
1-1/2	26	220
2	38	250
2-1/2	49	275
3	60	300
3-1/2	70	310
4	78	305
4-1/2	79	280

No.4

1/2	4	110
1	14	170
1-1/2	24	205
2	35	235
2-1/2	47	265
3	60	285
3-1/2	70	300
4	77	295
4-1/2	79	275

The average of these four tests is in

Table No.1 page 28.

FIRE-TUBE TESTS ON CREOSOTED WOOD

Wood treated for 30 minutes in September 1933

No. 1			No. 2		
Time min.	% loss in weight	Temp. degrees C.	Time	% loss in weight	Temp. degrees C.
1/2	4	125	1/2	4	120
1	14	185	1	13	180
1-1/2	23	215	1-1/2	22	215
2	34	240	2	32	250
2-1/2	43	260	2-1/2	40	265
3	53	280	3	50	285
3-1/2	62	295	3-1/2	58	295
4	70	300	4	65	305
4-1/2	80	280	4-1/2	71	300

No. 3		
1/2	5	125
1	15	185
1-1/2	25	215
2	35	240
2-1/2	46	260
3	58	285
3-1/2	69	290
4	76	290
4-1/2	90	280

Table No. 2,page 28, is the average of these tests.

FIRE-TUBE TESTS ON CREOSOTED WOOD

Wood treated for 60 minutes in September 1933.

No. 1

Time min.	% loss in weight	Temp. degrees C.
1/2	5	95
1	16	135
1-1/2	27	160
2	38	185
2-1/2	50	205
3	63	225
3-1/2	73	230
4	80	210
4-1/2	80	190

No. 2

Time min.	% loss in weight	Temp. degrees C.
1/2	7	130
1	20	200
1-1/2	33	240
2	46	265
2-1/2	60	285
3	72	300
3-1/2	79	295
4	80	270
4-1/2	80	245

No. 3

1/2	7	120
1	20	185
1-1/2	32	225
2	46	260
2-1/2	60	295
3	73	310
3-1/2	80	305
4	86	280
4-1/2	86	250

After running test number one the position of the pyrometer, at the top of the tube, was found to be wrong and this test was discarded.

Table No. 3 , page 29, is the average of tests 2 and 3.

FIRE-TUBE TESTS ON CREOSOTED WOOD

Wood treated for 90 minutes in September 1933

No. 1

Time min.	% loss in weight	Temp. degrees C.
1/2	5	120
1	16	180
1-1/2	28	210
2	39	235
2-1/2	50	250
3	62	260
3-1/2	73	260
4	79	255
4-1/2	80	240

No. 2

Time min.	% loss in weight	Temp. degrees C.
1/2	7	140
1	19	190
1-1/2	30	215
2	42	235
2-1/2	53	250
3	67	250
3-1/2	76	250
4	80	235
4-1/2	80	215

No. 3

1/2	7	135
1	18	190
1-1/2	27	215
2	38	230
2-1/2	50	240
3	62	255
3-1/2	72	255
4	79	250
4-1/2	80	230

Table No. 4 , page 29, is the average of these tests.

FIRE-TUBE TESTS ON CREOSOTED WOOD

Wood treated for 30 minutes in February 1934.

No. 1

Time min.	% loss in weight	Temp. degrees C.
1/2	7	145
1	17	185
1-1/2	27	210
2	37	215
2-1/2	48	240
3	60	250
3-1/2	70	255
4	78	250
4-1/2	80	230

No. 2

Time min	% loss in weight	Temp. degrees C.
1/2	5	100
1	17	160
1-1/2	29	190
2	42	215
2-1/2	56	235
3	69	240
3-1/2	76	240
4	80	230
4-1/2	80	215

No. 3

1/2	5	135
1	17	195
1-1/2	27	225
2	38	240
2-1/2	48	250
3	60	260
3-1/2	72	265
4	80	260
4-1/2	82	240

No. 4

1/2	5	115
1	15	155
1-1/2	26	190
2	38	210
2-1/2	49	220
3	60	230
3-1/2	71	235
4	77	230
4-1/2	80	215

Table No. 5 , page 30, is the average of these tests.

FIRE-TUBE TESTS ON CREOSOTED WOOD

Wood treated for 60 minutes in February 1934.

No. 1

Time min.	% loss in weight	Temp. degrees C.
1/2	7	140
1	20	190
1-1/2	31	215
2	45	227
2-1/2	55	240
3	67	250
3-1/2	75	250
4	79	230
4-1/2	97	210

No. 2

Time min.	% loss in weight	Temp. degrees C.
1/2	7	140
1	19	200
1-1/2	31	225
2	42	245
2-1/2	53	250
3	65	260
3-1/2	74	260
4	80	250
4-1/2	80	230

No. 3

1/2	8	130
1	22	180
1-1/2	35	200
2	48	210
2-1/2	60	220
3	71	225
3-1/2	99	220
4	99	200
4-1/2	99	185

The high loss in weight readings in tests 1 and 3 are due to the fact that the specimen was so thoroughly burned that pieces dropped from the specimen.

Table No. 6, page 30, is the average of these tests.

FIRE-TUBE TESTS ON CREOSOTED WOOD

Wood treated for 90 minutes in February 1934

No. 1			No. 2		
Time min.	% loss in weight	Temp. degrees C.	Time min.	% loss in weight	Temp. degrees C.
1/2	8	105	1/2	5	125
1	18	150	1	16	160
1-1/2	30	185	1-1/2	26	190
2	39	200	2	38	190
2-1/2	51	220	2-1/2	48	220
3	62	235	3	60	230
3-1/2	72	245	3-1/2	70	235
4	79	240	4	78	235
4-1/2	82	210	4-1/2	83	215

Table No. 7, page 31, is the average of these tests.

FIRE-TUBE TESTS ON ZINC CHLORIDE WOOD

Wood treated with zinc chloride for 30 minutes.

No. 1

Time min.	% loss in weight	Temp. Degrees C.
1/2	3	105
1	13	120
1-1/2	20	125
2	22	115
2-1/2	22	105
3	22	100

No. 2

Time min.	% loss in weight	Temp. degrees C.
1/2	5	95
1	15	110
1-1/2	20	110
2	20	100
2-1/2	20	100
3	20	95

No. 3

1/2	5	90
1	12	100
1-1/2	12	95
2	14	95
2-1/2	14	85
3		

No. 4

1/2	5	85
1	16	100
1-1/2	20	100
2	20	95
2-1/2	20	85
3	20	80

Table No. 8, page 31, is the average of these tests.

FIRE-TUBE TESTS ON ZINC CHLORIDE WOOD

Wood treated for 60 minutes.

No. 1

Time min.	% loss in weight	Temp. degrees C.
1/2	3	75
1	10	90
1-1/2	12	85
2	12	80
2-1/2	12	75
3	12	70

No. 2

Time min.	% loss in weight	Temp. degrees C.
1/2	2	70
1	10	90
1-1/2	12	85
2	12	80
2-1/2	12	75
3	12	70

No. 3

1/2	5	75
1	15	100
1-1/2	22	110
2	24	105
2-1/2	25	100
3	25	90

Table No. 9, page 32, is the average of these tests.

FIRE-TUBE TESTS ON ZINC CHLORIDE WOOD

Wood treated for 90 minutes.

No. 1

Time min.	% loss in weight	Temp. degrees C.
1/2	4	75
1	10	85
1-1/2	12	85
2	12	80
2-1/2	12	75
3	12	70

No. 2

Time min.	% loss in weight	Temp. degrees C.
1/2	2	70
1	9	85
1-1/2	10	80
2	10	80
2-1/2	10	70
3	10	70

No. 3

1/2	5	70
1	15	100
1-1/2	20	100
2	21	90
2-1/2	21	90
3	21	80

Table No. 10, page 32, is the average of these tests.

FIRE-TUBE TESTS ON WOLMANIZED WOOD

Wood treated for 90 minutes.

No. 1

Time min.	% loss in weight	Temp. degrees C.
1/2	3	70
1	10	85
1-1/2	12	80
2	12	80
2-1/2	12	75
3	12	70

No. 2

Time min.	% loss in weight	Temp. degrees C.
1/2	2	70
1	12	85
1-1/2	13	80
2	13	75
2-1/2	13	75
3	13	70

No. 3

1/2	4	70
1	10	90
1-1/2	15	90
2	16	85
2-1/2	17	85
3	18	80
3-1/2	18	75

Table No. 12, page 33, is the average of these tests.

FIRE-TUBE TESTS ON WOLMANIZED WOOD

Wood treated for 60 minutes.

No. 1

Time min.	% loss in weight	Temp. degrees C.
1/2	3	70
1	11	90
1-1/2	12	90
2	13	85
2-1/2	13	80
3	13	75

No. 2

Time min.	% loss in weight	Temp. degrees C.
1/2	4	75
1	13	95
1-1/2	17	95
2	17	90
2-1/2	17	80
3	17	80

No. 3

1/2	3	80
1	10	100
1-1/2	12	95
2	12	90
2-1/2	12	85
3	12	80

Table No. 11, page 33, is the average of these tests.

Table No. 3

Average of two burning tests on creosoted wood. Treated for 60 minutes. September 1933.

Time Minutes	Loss in weight Per cent	Temperature Degrees centigrade
1/2	7	125
1	20	192.5
1-1/2	32.5	232.5
2	46	262.5
2-1/2	60	290
3	72.5	305
3-1/2	79.5	300
4	83	275
4-1/2	83	247.5

Table No. 4

Average of three burning tests on creosoted wood. Treated 90 minutes. September 1933.

Time Minutes	Loss in weight Per cent	Temperature Degrees centigrade
1/2	6.3	131.6
1	17.6	186.6
1-1/2	28.3	213.3
2	39.6	233.3
2-1/2	51	246.6
3	63.6	255
3-1/2	73.6	255
4	79.3	246.6
4-1/2	80	228.3

Table No. 5

Average of four burning tests on creosoted wood. Treated 30 minutes. February 1934.

Time Minutes	Loss in weight Per cent	Temperature Degrees centigrade
1/2	5.5	123.7
1	16.5	173.7
1-1/2	27.2	201.2
2	38.7	220
2-1/2	50.2	236.2
3	62.2	236.2
3-1/2	72.2	248.7
4	78.7	242.5
4-1/2	80.5	225

Table No. 6

Average of three burning tests on creosoted wood. Treated 60 minutes. February 1934.

Time Minutes	Loss in weight Per cent	Temperatures Degrees centigrade
1/2	7.3	136.6
1	20.3	190
1-1/2	32.3	213.3
2	45	227.5
2-1/2	56	236.6
3	67.6	245
3-1/2	82.6	243.3
4	86	226.6
4-1/2	92	208.3

Table No. 7

Average of two burning tests on creosoted wood wood. Treated 90 minutes. February 1934

Time Minutes	Loss in weight Per cent	Temperature Degrees centigrade
1/2	6.5	115
1-1/2	17	155
2	28	187.5
2-1/2	49.5	220
3	61	232.5
3-1/2	71	240
4	78.5	237.5
4-1/2	82.5	220

Table No. 8

Average of four burning tests on zinc chloride wood. Treated 30 minutes.

Time Minutes	Loss in weight Per cent	Temperature Degrees centigrade
1/2	4.5	93.7
1	14	107.5
1-1/2	18	107.5
2	19	100
2-1/2	19	93.7
3	20.6	91.6

Specimens charred practically entire length (Fig. 3).

Table No. 9

Average of three burning tests on zinc chloride wood. Treated 60 minutes.

Time Minutes	Loss in weight Per cent	Temperature Degrees centigrade
1/2	3.3	73.3
1	11.6	93.3
1-1/2	15.3	93.3
2	16	88.6
2-1/2	16.3	83.3
3	16.3	76.6

Specimen charred for 3/4 of length.

(Fig. 3)

Table No. 10

Average of three burning tests on wood treated with zinc chloride. Treated for 90 minutes.

Time Minutes	Loss in weight Per cent	Temperature Degrees centigrade
1/2	3.6	71.6
1	11.3	90
1-1/2	14	88.3
2	14.3	81.6
2-1/2	14.3	76.6
3	14.3	73.3

Specimen charred for 1/2 of length

(Fig. 3).

Table No. 11

Average of three burning tests on Wolmanized wood. Treated 60 minutes.

Time Minutes	Loss in weight Per cent	Temperature Degrees centigrade
1/2	3.3	75
1	11.3	95
1-1/2	13.6	93.3
2	14	88.3
2-1/2	14	81.6
3	14	78.3

Specimen charred for 3/4 of length

(Fig. 4)

Table No. 12

Average of three burning tests on Wolmanized wood. Treated 90 minutes.

Time Minutes	Loss in weight Per cent	Temperatures Degrees centigrade
1/2	3	70
1	10.6	86.6
1-1/2	13.3	83.3
2	13.6	80
2-1/2	14	78.3
3	14.3	73.3

Specimen charred for 1/2 of length

(Fig. 4)

EXPLANATION OF CHARTS

Chart No. 1

Loss in weight plotted against time. Untreated wood and creosoted wood treated 30, 60 and 90 minutes in September 1933.

All creosoted wood curves follow the untreated wood curves very closely, the creosote causing very little difference in the rate of burning.

Attention is called to Curve C. This curve shows a higher loss than Curve D which might be caused by a slight difference in the character of the wood thereby causing a greater absorption of creosote and ahigher rate of burning.

All these specimens ignited easily and the flame travelled very rapidly to the top of the tube. All specimens completely destroyed.

Chart No. 1-A

Temperature plotted against time. Untreated wood and creosoted wood treated 30, 60 and 90 minutes in September 1933.

These curves show the temperature obtained at the top of the tube. They follow the same general trend as the loss in weight curves.

Chart No. 2

Loss in weight plotted against time. Specimen treated with creosote,in February 1934, and burned in the fire-tube in March 1934.

The 90 minute curve(C) falls between the 30 and 60 minute curves.

Chart No. 2-A

Temperatures plotted against time. Creosoted wood treated 30, 60 and 90 minutes, February 1934.I this chart the curve for the 90 minute treating falls below both the 30 and 60 minute curves.

Chart No. 3

Loss in weight plotted against time. Zinc chloride treatment for 30,60 and 90 minutes. There is no question that different amounts of preservative were absorbed by these specimens. The curve C having the greatest absorption of zinc chloride shows the least loss in weight.

Chart No 3-A

Temperatures plotted against time. Zinc chloride treatment for 30,60 and 90 minutes. Temperature curves follow the same general trend as loss in weight curves. The greater the absorption of zinc chloride less burning of the wood takes place and

therefore lower temperatures.

Chart No.4

Loss in weight plotted against time. Wolman salt treatment for 60 and 90 minutes. The two curves are practically the same but the 90 minute curve shows a smaller loss in weight.

Chart No. 4-A

Temperatures plotted against time. Wolman salt treatment for 60 and 90 minutes. The 90 minute curve is considerably below the 60 minute curve.

Chart No. 5

Curve A -- untreated wood.

Curve B -- creosoted wood, 90 minute treatment in September 1933

Curve C -- creosoted wood, 90 minute treatment in February 1934

Curve D -- zinc chloride wood, 90 minute treatment.

Curve E -- Wolmanized wood, 90 minute treatment.

Curves B and C give a comparison between freshly creosoted wood and creosoted wood that has had time for thorough drying. There seems to be very

little difference in the rate of burning. The creosoted specimens have higher rates of burning than the untreated wood but for all practical purposes could be considered the same.

Curves D and E show very clearly that zinc chloride and Wolman salt are fire-retardants. The Wolman salt used being somewhat better than zinc chloride.

In burning all specimens the flame remained under the stick for one minute. After the removal of the flame the creosoted and untreated wood continued to burn and were completely destroyed.

Upon removing the flame from the zinc chloride and the Wolmanized specimens the burning continued but for a very short time, usually 1/4 of a minute. The curves show very little loss in weight after 1-1/2 minutes.

Chart No. 5-A

Temperature curves of the same specimens as in Chart No. 5. Attention is called to Curves D and E. The temperature begins to fall immediately upon the removal of the flame showing that there is very slight propagation of the flame towards the top of the tube.

CONCLUSIONS

1. Zinc chloride and Wolman salt in addition to their preservative properties have also a fire-retardant effect and should be used, other considerations being equal, in mines where the fire-hazard is of major importance.

2. There is little difference, from the fire-hazard standpoint, between untreated and creosoted wood.

3. Freshly creosoted wood has a slightly higher burning rate than thoroughly dried creosoted wood.

RECOMMENDATIONS

1. A further study on zinc chloride and Wolman salt as fire-retardants, showing preservative injected in pounds per cubic foot and cost data on same.

2. A more complete study on the inflammability of creosoted woods. This should include:

1. Pounds injected per cubic foot.

2. Freshly creosoted and thoroughly dried creosoted specimens.

3. Creosote in combination with a fire-retardant

chemical or preservative.

4. Use of the fire-tube along with small-scale built-up assemblies of square-sets, shaft and drift timbers.

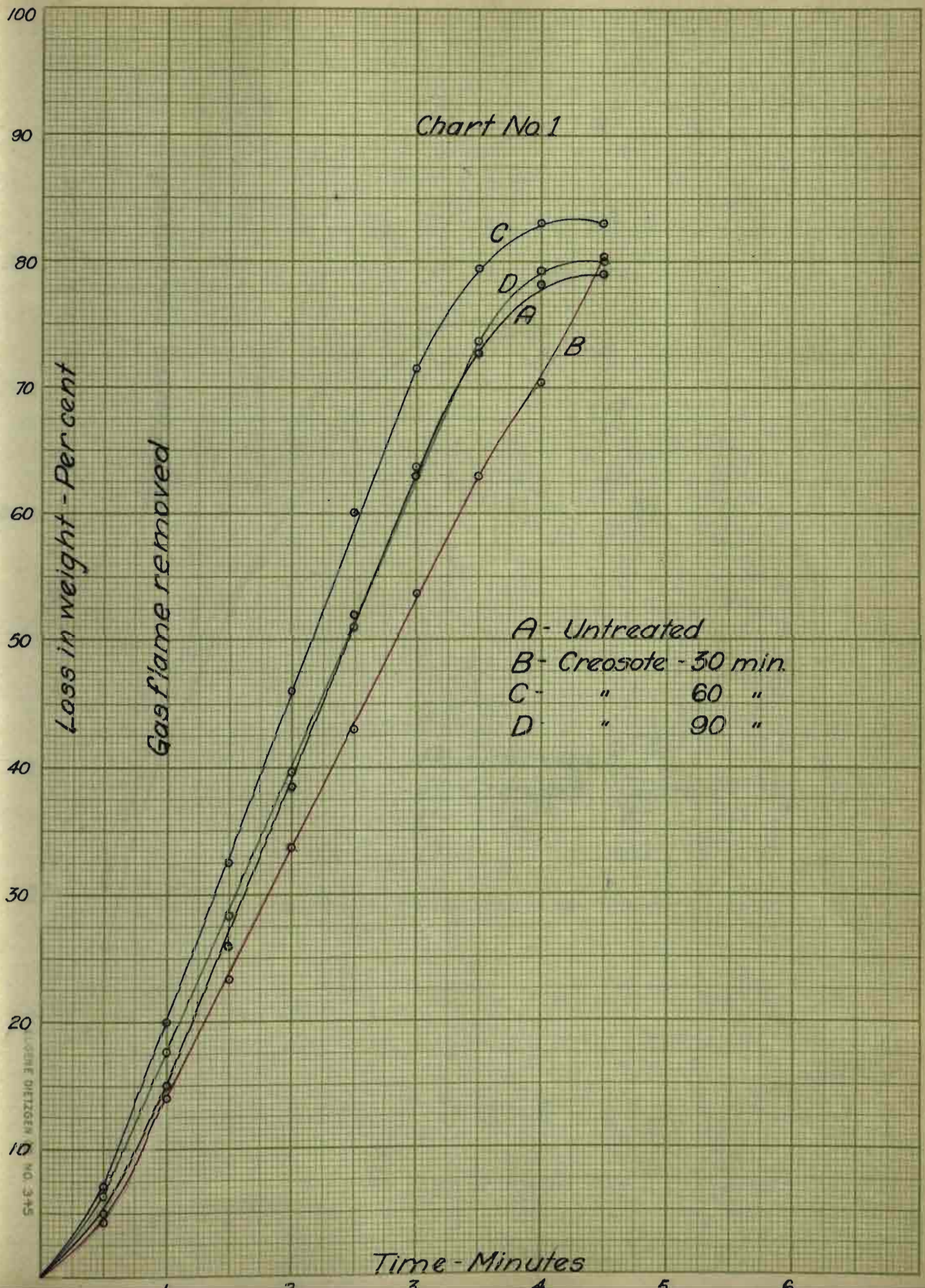


Chart No 1
Loss in weight - Per cent
Gas flame removed
Time - Minutes
A - Untreated
B - Creosote - 30 min.
C - " 60 "
D " 90 "
100
90
80
70
60
50
40
30
20
10
1
2
3
4
5
6

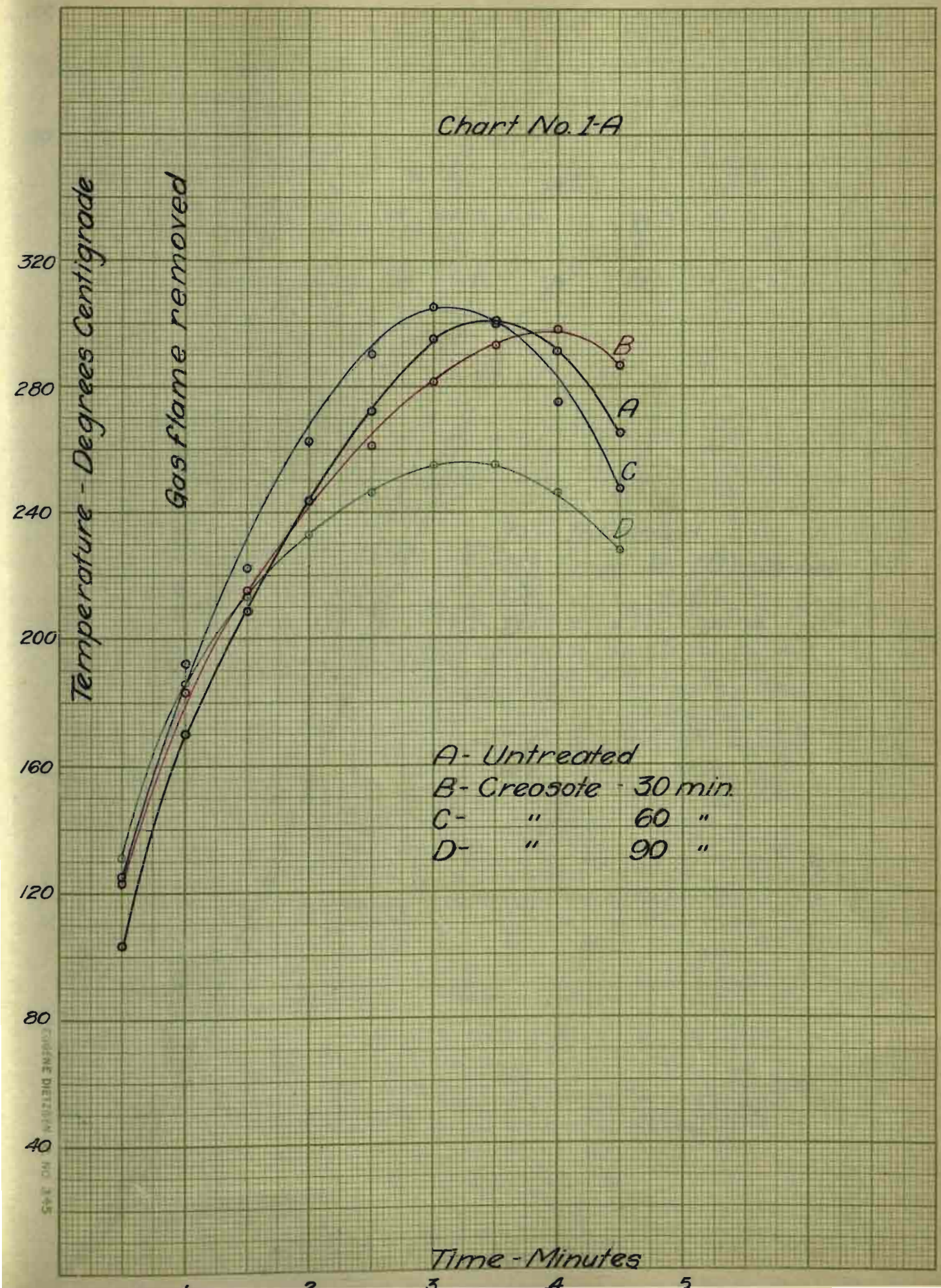


Chart No. 1-A
Temperature - Degrees Centigrade
Gas flame removed
320
280
240
200
160
120
80
40
A
B
C
D
A- Untreated
B- Creosote - 30 min.
C- " 60 "
D- " 90 "
Time - Minutes
1
2
3
4
5

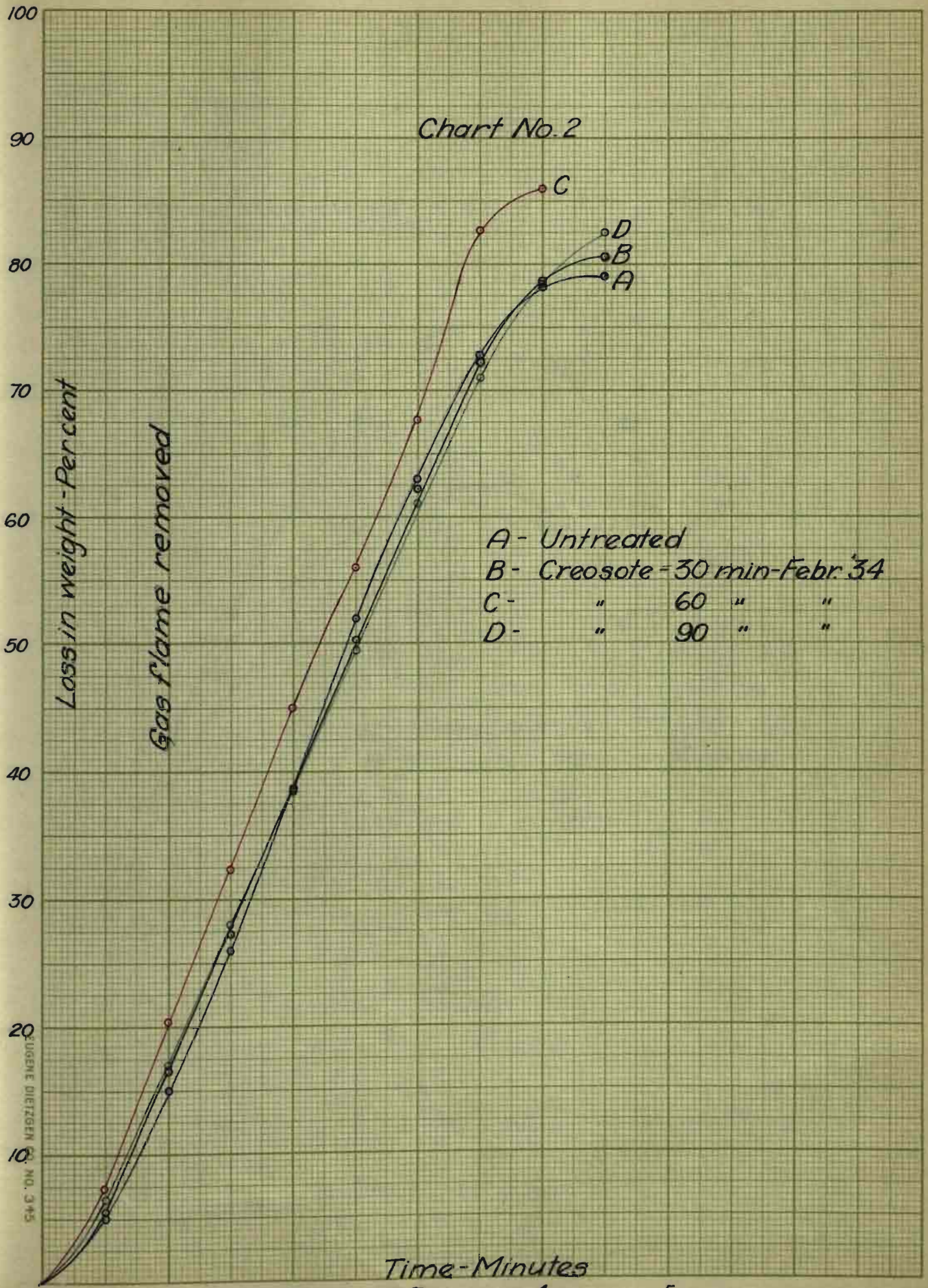


Chart No. 2
Loss in weight - Percent
Gas flame removed
Time - Minutes
100
90
80
70
60
50
40
30
20
10
C
D
B
A
A - Untreated
B - Creosote - 30 min - Febr. 34
C - " 60 " "
D - " 90 " "
EUGENE DIETZGEN CO. NO. 345

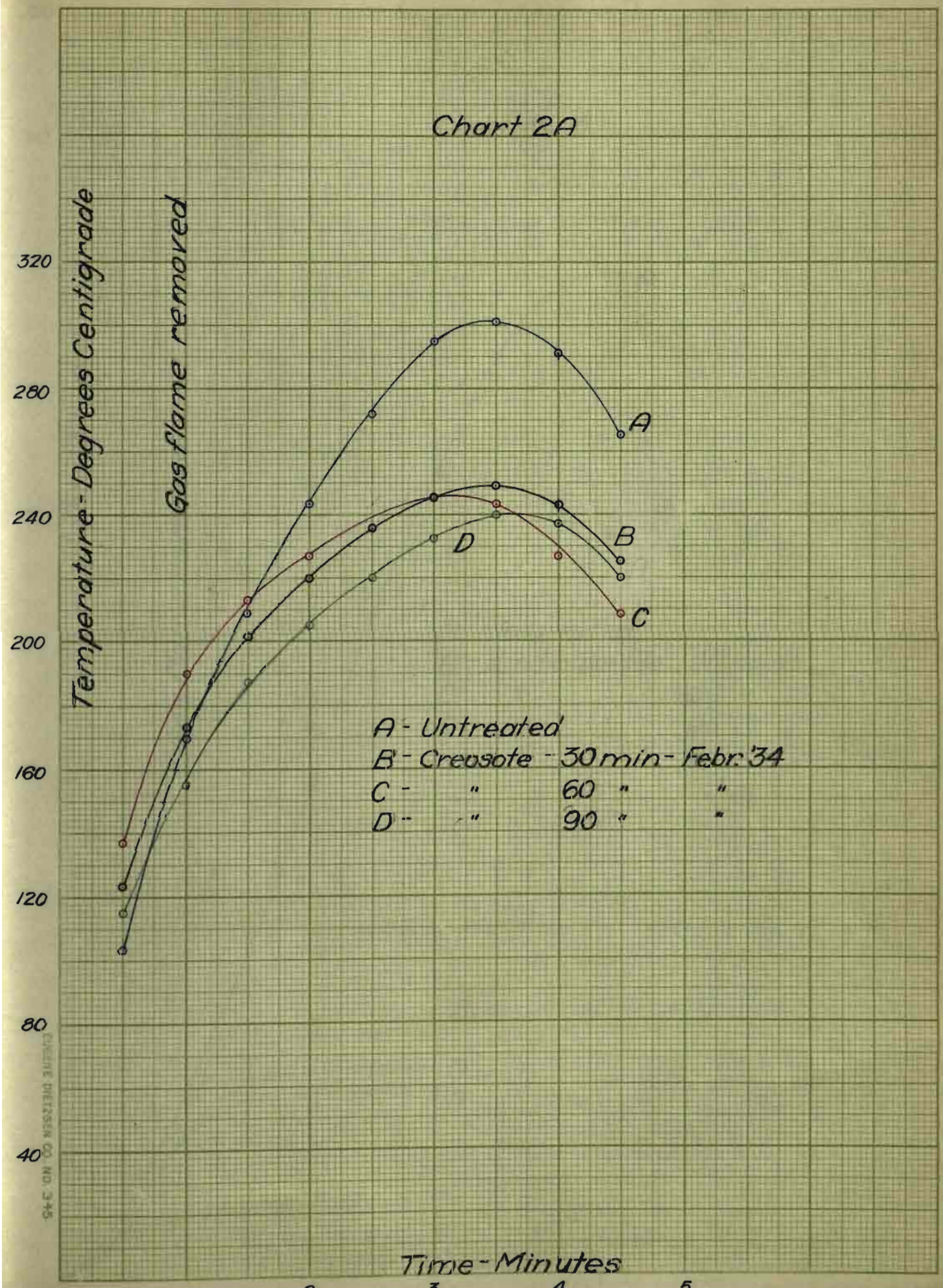


Chart 2A
Temperature - Degrees Centigrade
Gas flame removed
320
280
240
200
160
120
80
40
A
B
C
D
A - Untreated
B - Creosote - 30 min - Febr. 34
C - " 60 " "
D - " 90 " "
Time - Minutes

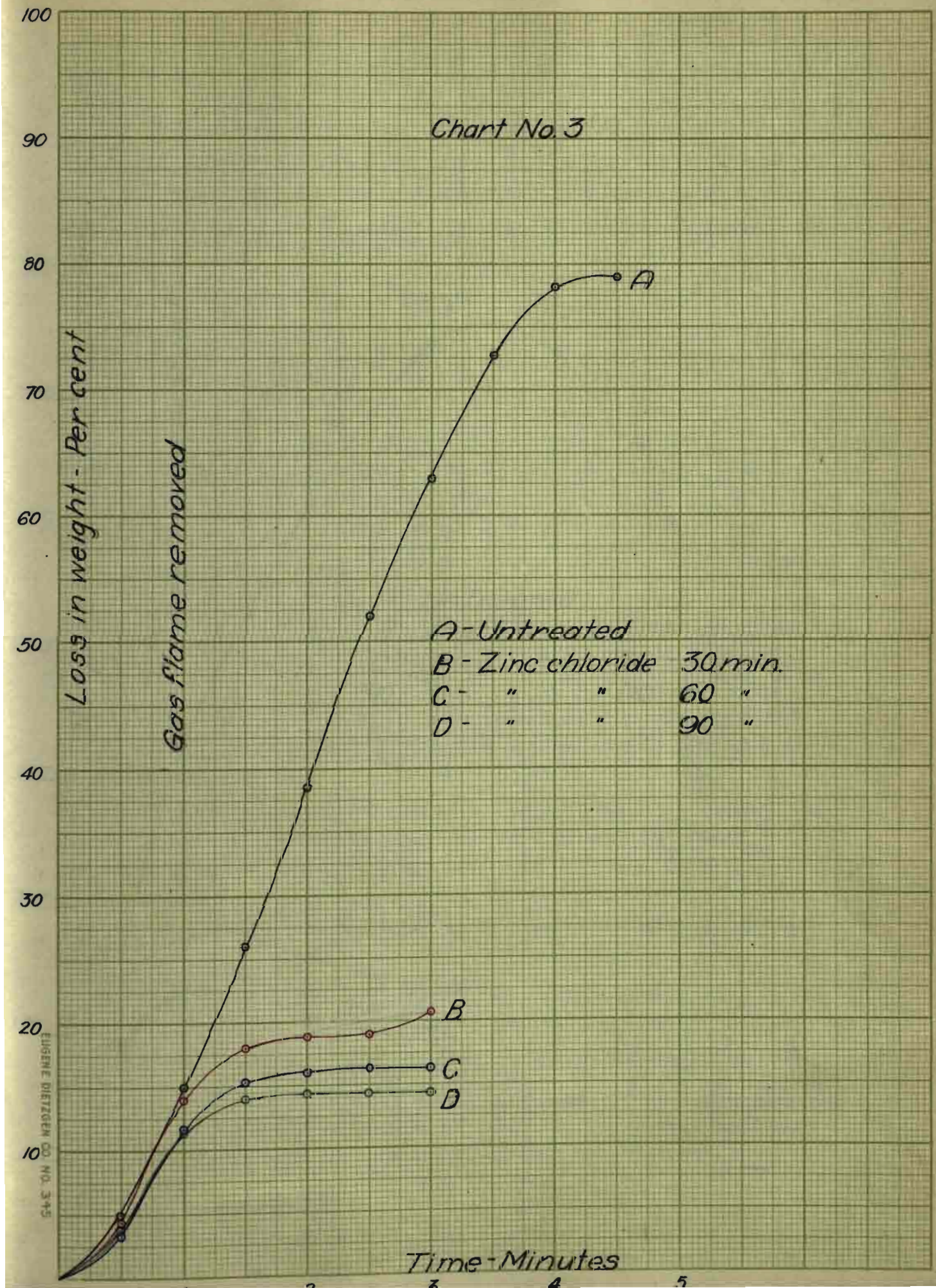


Chart No. 3
Loss in weight - Per cent
Gas flame removed
100
90
80
70
60
50
40
30
20
10
A
B
C
D
A - Untreated
B - Zinc chloride 30 min.
C - " " 60 "
D - " " 90 "
Time - Minutes
EUGENE DIETZGEN CO. NO. 345

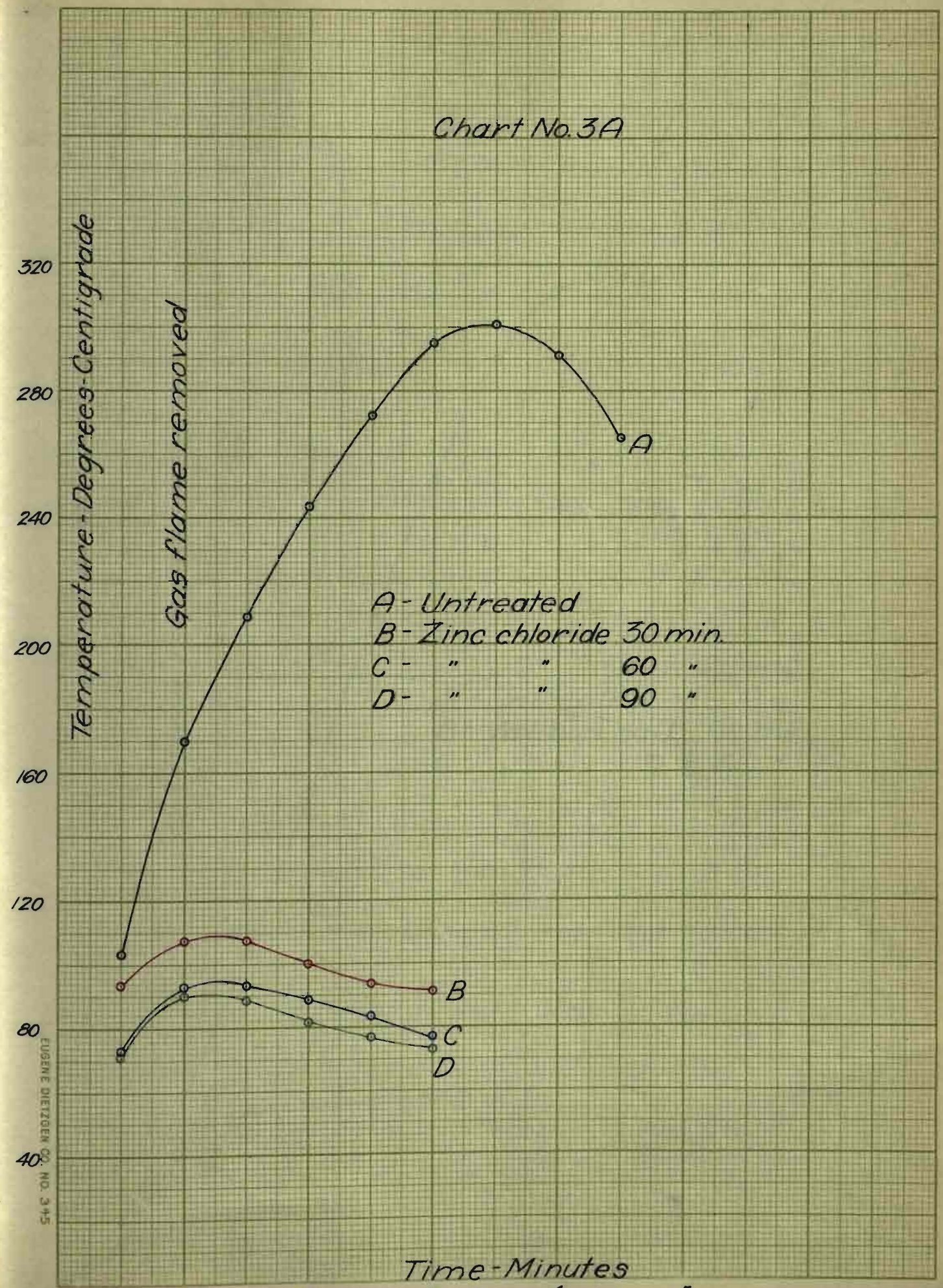


Chart No. 3A
Temperature - Degrees - Centigrade
Gas flame removed
320
280
240
200
160
120
80
40
A - Untreated
B - Zinc chloride 30 min.
C - " " 60 "
D - " " 90 "
A
B
C
D
Time - Minutes
EUGENE DIETZGEN CO. NO. 345

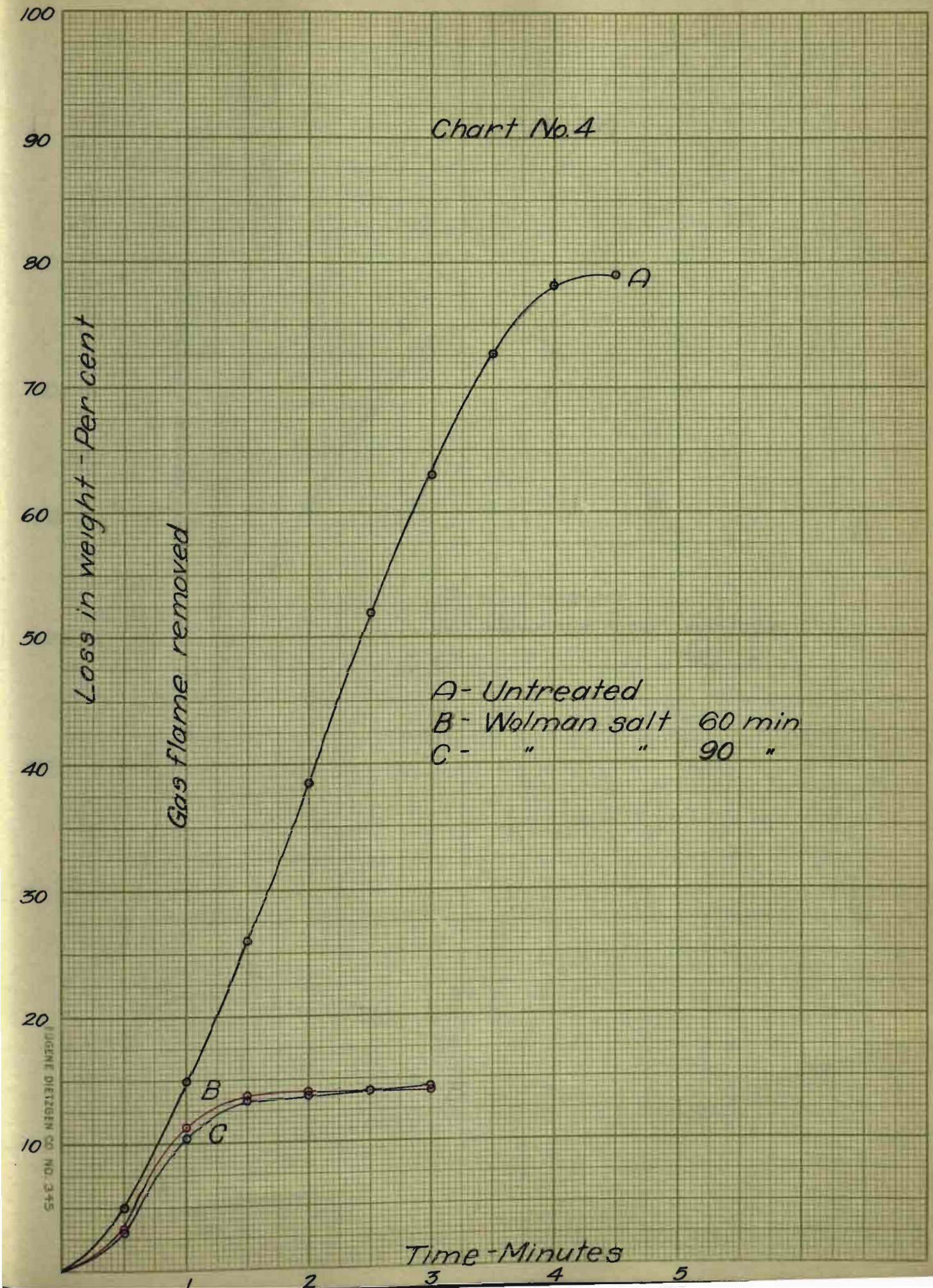


Chart No. 4
Loss in weight - Per cent
Gas flame removed
100
90
80
70
60
50
40
30
20
10
A
B
C
A - Untreated
B - Wolman salt 60 min
C - " " 90 "
Time - Minutes
1
2
3
4
5
EUGENE DIETZGEN CO. NO. 345

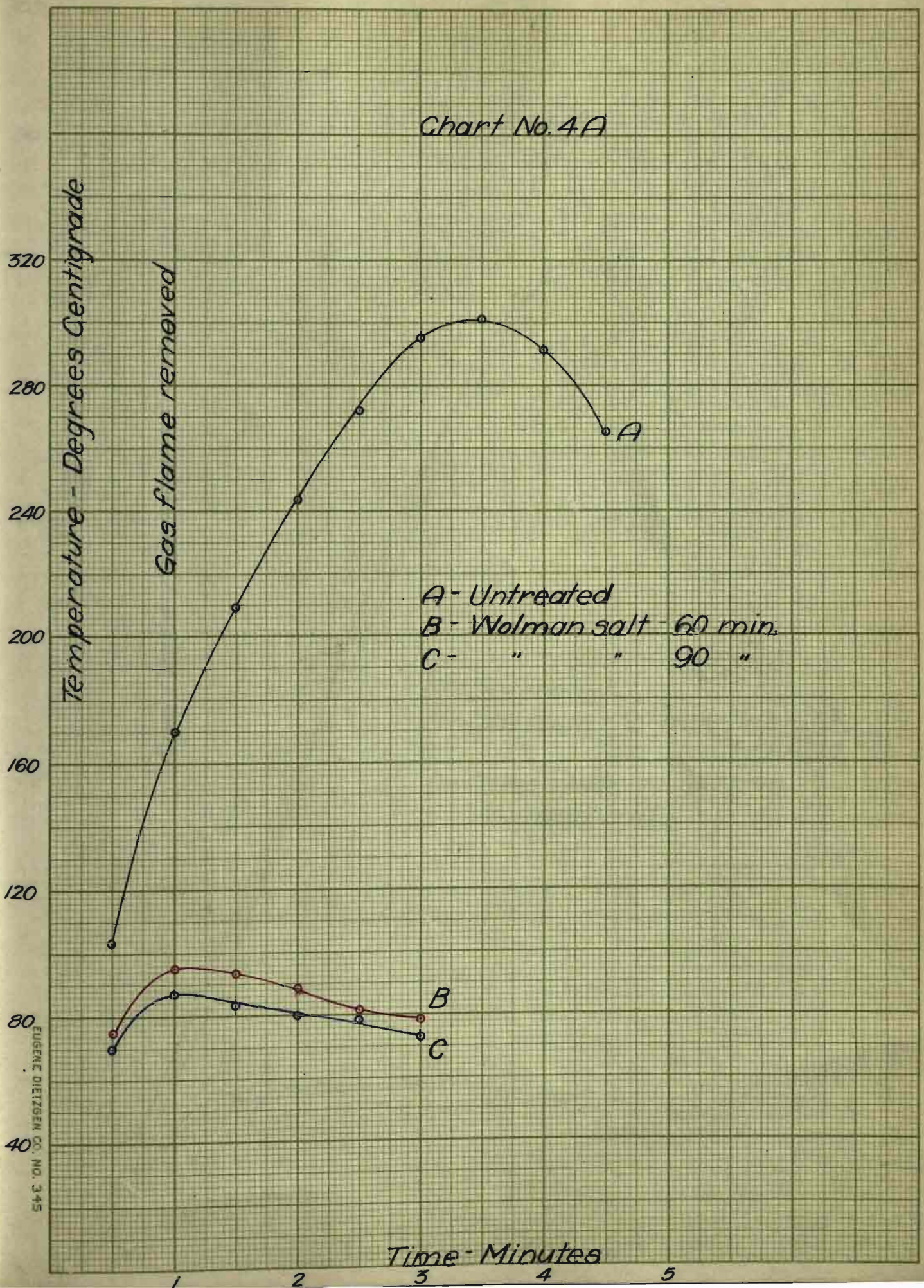


Chart No. 4A
Temperature - Degrees Centigrade
Gas flame removed
320
280
240
200
160
120
80
40
A
B
C
A - Untreated
B - Wolman salt - 60 min.
C - " " 90 "
Time - Minutes
1
2
3
4
5
EUGENE DIETZGEN CO. NO. 345

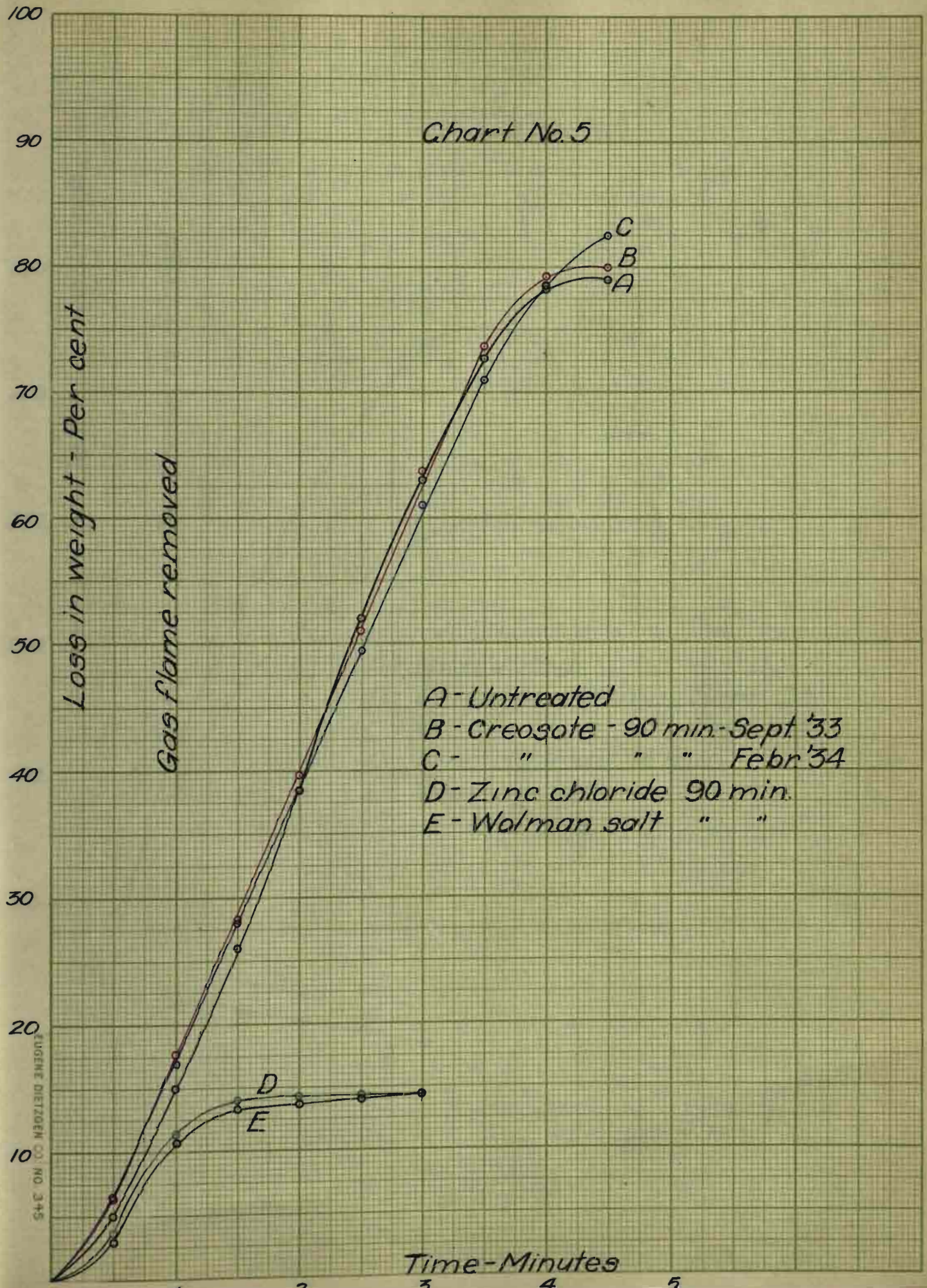


Chart No. 5
Loss in weight - Per cent
Gas flame removed
100
90
80
70
60
50
40
30
20
10
C
B
A
D
E
A - Untreated
B - Creosote - 90 min. - Sept '33
C - " " " Febr '34
D - Zinc chloride 90 min.
E - Wolman salt " "
Time - Minutes
EUGENE DIETZGEN CO. NO 345

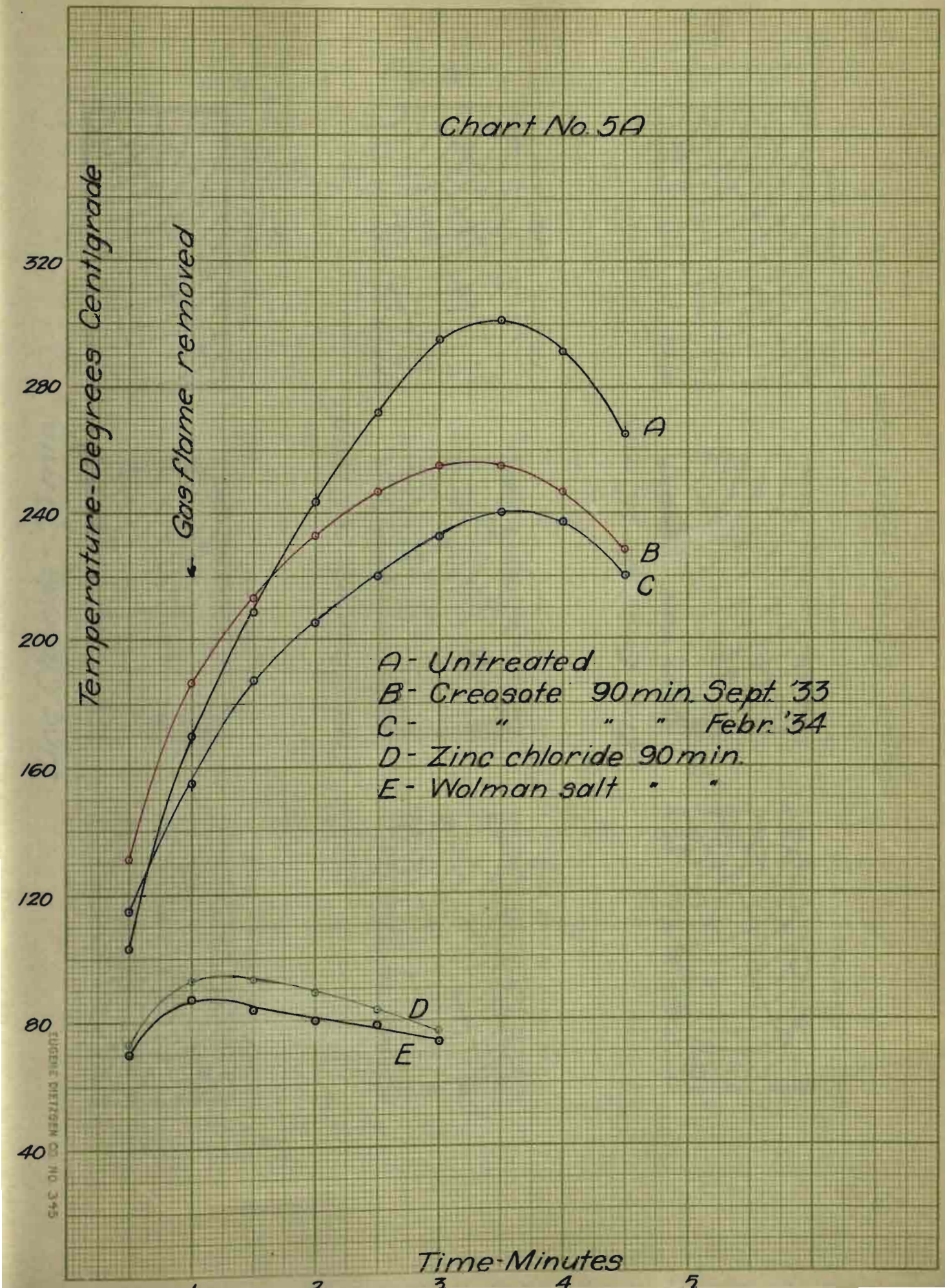
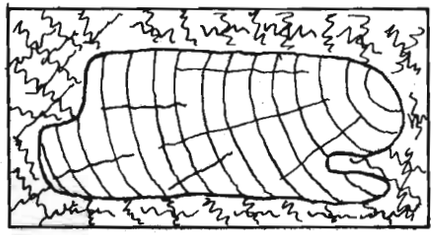


Chart No. 5A
Temperature-Degrees Centigrade
← Gas flame removed
320
280
240
200
160
120
80
40
A
B
C
D
E
A - Untreated
B - Creosote 90 min. Sept. '33
C - " " " Febr. '34
D - Zinc chloride 90 min.
E - Wolman salt " "
Time-Minutes
EUGENE DIETZGEN CO. NO. 345

Zinc Chloride - 30 min.



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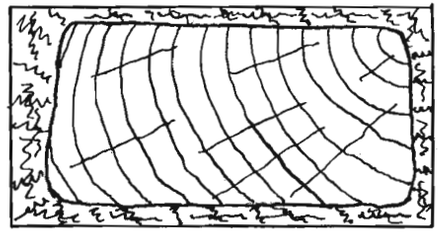

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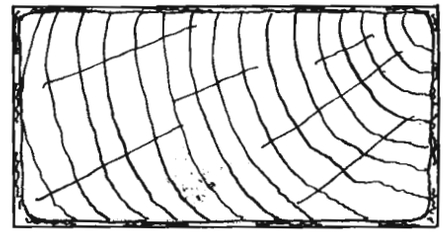

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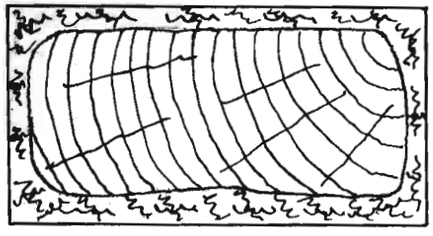
Zinc Chloride - 60 min.



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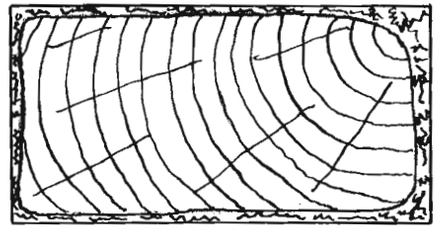

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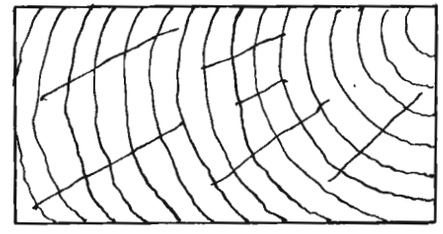
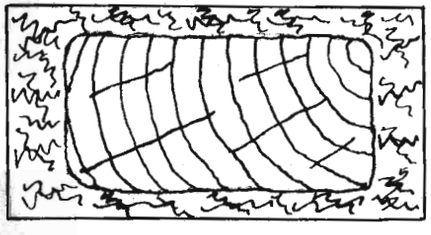


1in. from upper end

Fig. 3

Zinc Chloride - 90 min.



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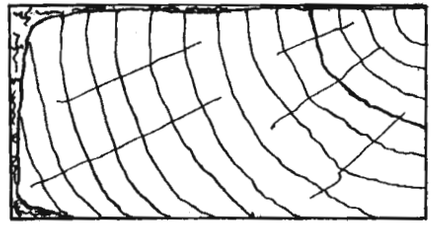

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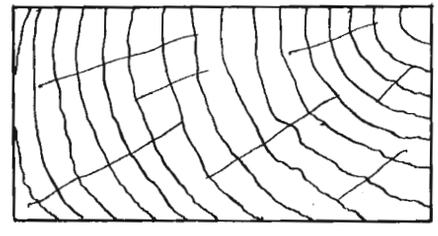
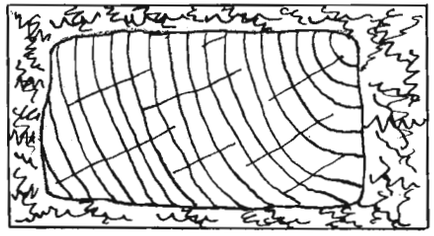


1in. from upper end

Scale - 3 times actual size

Fig. 4

Wolman salt - 60 min.



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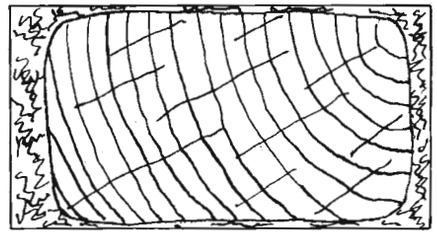

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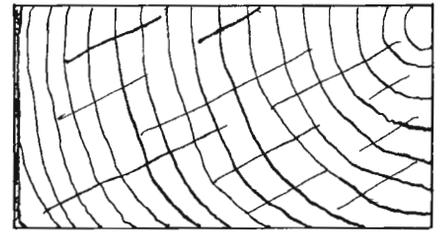
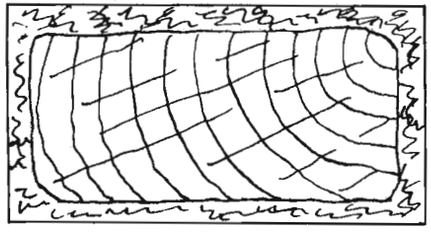


1 in. from upper end

Wolman salt - 90 min.



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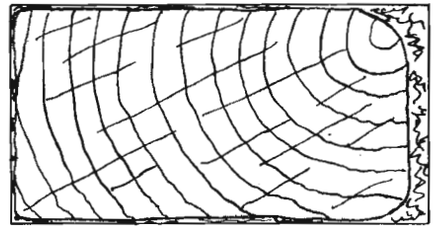

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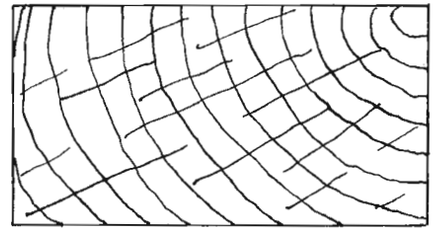

1 in. from upper end

Scale - 3 times actual size

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